

What is Claimed is:

1. A starting apparatus for an engine comprising a traction-roller speed reducer and a rotation-power transmission means, which are provided between a starter motor and the engine and in series with reference to the power transmission direction, the traction-roller speed reducer comprising: a housing; an input shaft that can rotate freely with respect to the housing, a center roller that is concentric with the input shaft and connected to an end of the input shaft and to which the rotation force is freely transmitted and whose outer peripheral surface is taken to be a drive-side cylindrical surface; an outer ring that is located around the center roller and whose inner peripheral surface is taken to be the driven-side cylindrical surface that rotates relative to the center roller; an output shaft that is concentric with the outer ring and where one end is linked to the outer ring such that rotation force can be freely transmitted and is supported such that it rotates freely with respect to the housing; a plurality of pivot shafts that are located in the annular space between the drive-side cylindrical surface and the driven-side cylindrical surface such that they are arranged parallel with the center roller; and a plurality of intermediate rollers that are supported by the respective pivot shafts such that they rotate freely and whose outer peripheral surfaces are taken to be

the driving-force-transmission cylindrical surfaces, respectively,  
the center of the center roller being made eccentric with the center  
of the outer ring, whereby the width dimension of the annular space is not  
uniform in the circumferential direction, and one of the plurality of  
intermediate rollers being a movable roller that is supported such that it  
can move freely in the circumferential direction inside the annular space  
and the remaining intermediate rollers being fixed rollers, the intermediate  
roller that is the movable roller will freely move toward the narrow-width  
section of the annular space when the center roller and outer ring rotate in  
a specified direction,

wherein by elastically pressing the intermediate roller that is the  
movable roller in the traction-roller speed reducer toward the  
narrow-width section of the annular space, a pre-load is applied for  
causing contact pressure to occur at the areas of contact between the  
driving-force-transmission cylindrical surface on the intermediate roller  
that is the movable roller and the drive-side cylindrical surface and  
driven-side cylindrical surface, even in the no-load state, and

wherein when the maximum value of the circumferential speed of  
the drive-side cylindrical surface during operation is taken to be  $U_{max}$   
[m/sec], and the average value of the contact pressure due to preloading at

the areas of contact between the driven-side cylindrical surface and the driving-force-transmission cylindrical surface on the intermediate roll r that is the movable roller is taken to be  $P_{mean}$  [GPa],  $P_{mean} \leq 0.3$  [GPa] and  $P_{mean} > \{(U_{max})^{1/2}\}/9$  are satisfied.

2. A starting apparatus for an engine comprising a traction-roller speed reducer and a rotation-power transmission means, which are provided between a starter motor and the engine and in series with reference to the power transmission direction, the traction-roller speed reducer comprising: a housing; an input shaft that can rotate freely with respect to the housing, a center roller that is concentric with the input shaft and connected to an end of the input shaft and to which the rotation force is freely transmitted and whose outer peripheral surface is taken to be a drive-side cylindrical surface; an outer ring that is located around the center roller and whose inner peripheral surface is taken to be the driven-side cylindrical surface that rotates relative to the center roller; an output shaft that is concentric with the outer ring and where one end is linked to the outer ring such that rotation force can be freely transmitted and is supported such that it rotates freely with respect to the housing; a plurality of pivot shafts that are located in the annular space between the drive-side cylindrical surface and the driven-side cylindrical surface such

that they are arranged parallel with the center roller; and a plurality of intermediate rollers that are supported by the respective pivot shafts such that they rotate freely and whose outer peripheral surfaces are taken to be the driving-force-transmission cylindrical surfaces, respectively,

the center of the center roller being made eccentric with the center of the outer ring, whereby the width dimension of the annular space is not uniform in the circumferential direction, and one of the plurality of intermediate rollers being a movable roller that is supported such that it can move freely in the circumferential direction inside the annular space and the remaining intermediate rollers being fixed rollers, the intermediate roller that is the movable roller will freely move toward the narrow-width section of the annular space when the center roller and outer ring rotate in a specified direction,

wherein by elastically pressing the intermediate roller that is the movable roller in the traction-roller speed reducer toward the narrow-width section of the annular space, a pre-load is applied for causing contact pressure to occur at the areas of contact between the driving-force-transmission cylindrical surface on the intermediate roller that is the movable roller and the drive-side cylindrical surface and driven-side cylindrical surface, even in the no-load state, and

wherein when and the average value of the contact pressure at the areas of contact between the driven-side cylindrical surface and the driving-force-transmission cylindrical surface on the intermediate roller that is the movable roller is taken to be  $P_{mean}$  [GPa],  $P_{mean} > 0.3$  [Gpa] is satisfied.

3. The starting apparatus for engine of any one of Claims 1 to 2, wherein the contact surface pressure at the radially inner contact areas that are the areas of contact between the driving-force-transmission cylindrical surfaces and the drive-side cylindrical surface, and the radially outer contact areas that are the areas of contact between the driving-force-transmission cylindrical surfaces and the driven-side cylindrical surface are substantially the same to each other, with a difference within  $\pm 20\%$  therebetween.

4. The starting apparatus for engine of anyone of Claims 1 to 3, wherein the radially inner contact areas that are the areas of contact between the driving-force-transmission cylindrical surfaces and the drive-side cylindrical surface is different in width from the radially outer contact areas that are the areas of contact between the driving-force-transmission cylindrical surfaces and the driven-side cylindrical surface.

5. The starting apparatus for engine of Claim 4, wherein the width of the radially outer contact areas are smaller than the width of the radially inner contact areas.
6. The starting apparatus for engine of Claim 5, wherein axial part of the inner peripheral surface of the outer race is radially inwardly recessed generally circumferentially comparing with the other part to form a recess.
7. The starting apparatus for engine of Claim 6, wherein the recess is formed in a portion facing the axially intermediate portion of the driving-force-transmission cylindrical surfaces, and wherein the driving-force-transmission cylindrical surfaces come into contact with the driven-side cylindrical surface at a portion near the axial opposite ends of the driving-force-transmission surfaces.
8. The starting apparatus for engine of anyone of Claims 1 to 3, wherein recesses and lands are alternately formed in the circumferential direction in a portion of the inner peripheral surface of the outer race in contact with the driving-force-transmission cylindrical surfaces such that the recesses and lands are tilted in the axial direction.
9. The starting apparatus for engine of Claim 8, wherein the lands are larger in area than the recess.

10. The starting apparatus for engine of anyone of Claims 1 to 9, wherein crowning is provided on the driving-force-transmission cylindrical surfaces.

11. The starting apparatus for engine of anyone of Claims 1 to 10, wherein the rotation power transmission means comprises a first pulley fixed to the output shaft of the traction roller type transmission, a second pulley fixed to the rotating shaft of the engine, and an endless belt extending between the first and second pulleys.

12. The starting apparatus for engine of anyone of Claims 1 to 10, wherein the rotation power transmission means comprises a small reduction gear fixed to the output shaft of the traction roller type transmission and a large reduction gear fixed to the rotating shaft of the engine and meshed with the smaller reduction gear.

13. The starting apparatus for engine of anyone of Claims 1 to 12, wherein the output shaft and the outer race in the traction roller type speed reducer are substantially concentric with each other and rotatable relative to each other, and wherein at least part of the base end of the output shaft enters into the radially inside of the outer race, and wherein a one-way clutch is provided between the outer peripheral surface of the base end of the output shaft and the outer race, such that the one-way

clutch is connected only when the rotation of the outer race based on the power-on to the startcr motor is transmitted to the output shaft.

14. The starting apparatus for engine of Claim 13, wherein the one-way clutch is a roller clutch, and wherein a ball bearing of a single-row deep groove type is provided together with the one-way clutch between the inner peripheral surface of the cylindrical portion that is rotated together with the outer race and the outer peripheral surface of the base end of the output shaft such that they are axially displaced from each other and in parallel to each other with reference to the rotating power transmission dircction.

15. An electric motor integral with a speed reducer comprising an electric motor, a rotating drive-shaft of the electric motor, an input shaft provided integral with the tip end of the rotating drive-shaft, and a speed reducer for taking the rotation of the input shaft through an output shaft after reduction, the speed reducer being a traction-roller speed reducer comprising: a center roller that is integral with the input shaft; an outer ring that is located around the center roller and eccentric relative to the center roller; at least two fixed rollers and one movable roller that are located in the annular space between the drive-side cylindrical surface that is the outer peripheral surface of the center roller and the driven-side

cylindrical surface that is the inner peripheral surface of the outer race such that the radial width of the annular space is uneven in the circumferential direction such that the outer peripheral surfaces are taken to be the driving-force-transmission cylindrical surfaces,

wherein the fixed rollers are only rotatable with its center on the support shaft while the movable roller is rotatable with its center on the support shaft and movable at least circumferentially in the annular space, and wherein the movable roller is elastically pressed toward the narrow-width section of the annular space,

wherein the output shaft and outer race are substantially concentric with each other and movable relative to each other in the traction roller speed reducer, wherein at least part of the base end of the output shaft enters into the radial inside of the outer race, wherein one-way clutch is provided between the outer peripheral surface of the base end of the output shaft and the outer race, such that the one-way clutch is connected only when the rotation of the outer race based on the power-on to the elastic motor is transmitted to the output shaft.

16. The electric motor integral with the speed reducer of Claim 15, wherein the one-way clutch is a roller clutch, and wherein a ball bearing of a single-row deep groove type is provided together with the one-way

**clutch between the inner peripheral surface of the cylindrical portion that is rotated together with the outer race and the outer peripheral surface of the base end of the output shaft such that they are axially displaced from each other and in parallel to each other with reference to the rotating power transmission direction.**